LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

CFA20 | Curdworth to Middleton

Flood risk assessment (WR-003-020)

Water resources

November 2013

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Department for Transport

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Appendix WR-003-020

Environmental topic:	Water resources and flood risk assessment	WR
Appendix name:	Flood risk assessment	003
Community forum area:	Curdworth to Middleton	020

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 The water resources and flood risk assessment appendices comprise of four parts. The first of these is a route-wide appendix (Appendix WR-001-000).

1.1.2 Three specific appendices for each community forum area (CFA) are also provided. For the Curdworth to Middleton area (CFA20) these are:

- a water resources assessment (Appendix WR-002-020); and
- a Flood Risk Assessment (FRA) i.e. this appendix; and
- a river modelling report (Appendix WR-004-013).

1.1.3 Maps referred to throughout the water resources and FRA appendices are contained in the Volume 5 water resources map book.

1.2 Scope of this assessment

1.2.1 This FRA considers the assessment of flood risk in this study area, which is defined as the area within 1km of the route within CFA20. The assessment has been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1], which aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe without increasing flood risk elsewhere.

1.2.2 This FRA presents baseline (current day) flood risk and post-construction flood risk as a result of the Proposed Scheme and has been written to demonstrate the relative change in flood risk as a result of the Proposed Scheme. Whilst all change in risk status is highlighted, the focus of the document is on the change in risk status to local receptors, particularly existing infrastructure.

1.2.3 A risk-based methodology has been adopted through the application of the source-pathway-receptor model. This model has been used to identify the cause of 'sources' of flooding to and from a development. The identification is based on a review of local conditions and consideration of the effects of climate change.

1.2.4 In order for there to be a flood risk, all the elements of the model (a flood source, a pathway and a receptor) must be present. Furthermore, effective mitigation can be provided by removing one element of the model, for example by removing the pathway or receptor.

1.2.5 Receptors may include people and their properties, business and infrastructure, and the built and natural environment within the range of the flood source which are connected to the source of flooding by a pathway.

[1] Department for Communities and Local Government (2012), *National Planning Policy Framework.*

1.2.6 This FRA has been completed to inform the Environmental Statement (ES) for the works, which will be a key part of the hybrid Bill submission required for the Proposed Scheme. The hybrid Bill is necessary for powers to build the railway, powers to buy land and for planning consent.

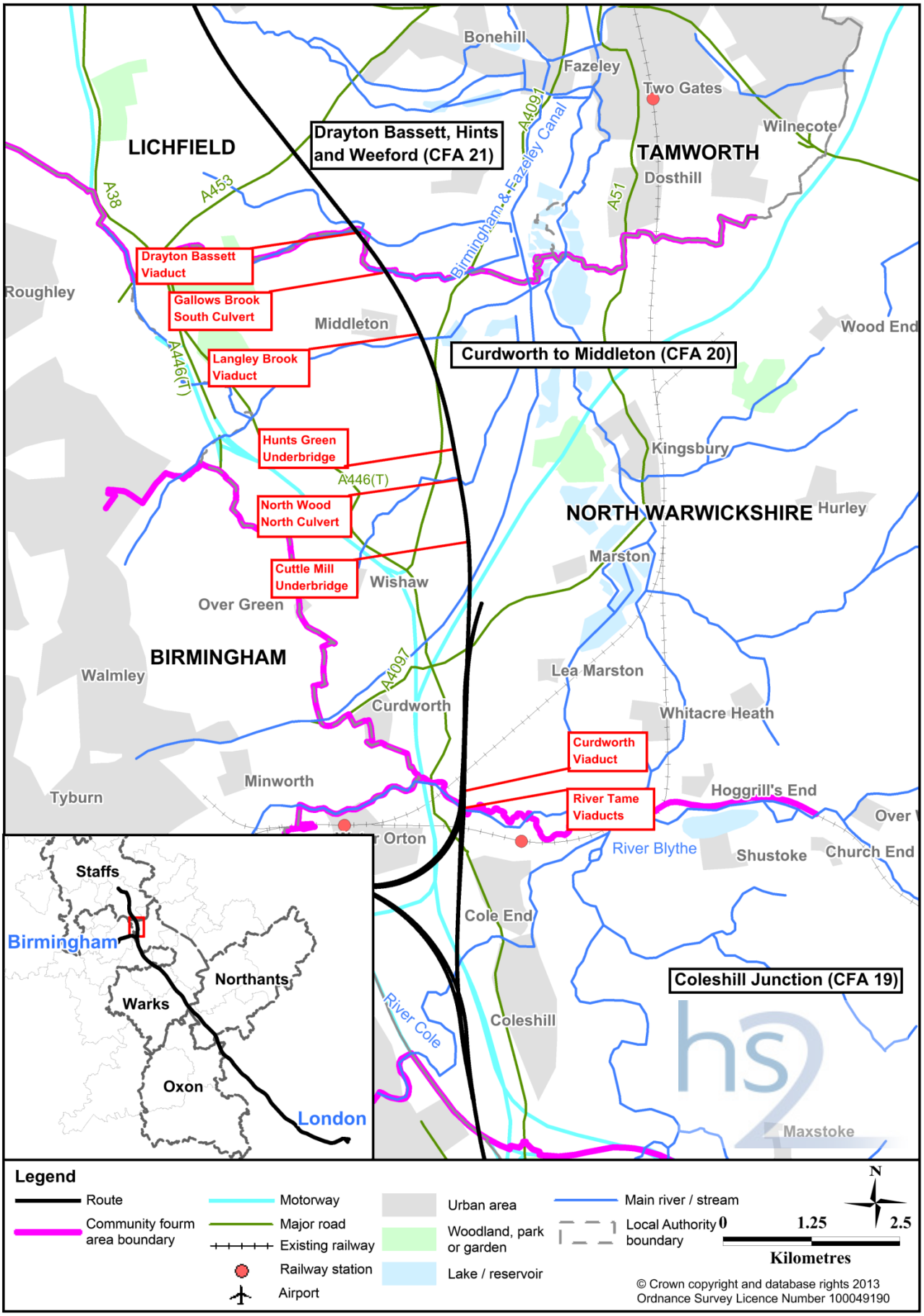
1.2.7 The Proposed Scheme will cross numerous surface water features within this study area, which are the River Tame and its tributaries, including Langley Brook, additional ordinary watercourses and Gallows Brook along the northern boundary of CFA20.

1.3 Location

1.3.1 In this FRA, the study area covers a 7.8km section of the Proposed Scheme in the borough of North Warwickshire, where it passes to the north-east of the Birmingham urban area. The southern boundary of the area is defined by the River Tame, near Coleshill Parkway and the boundary between Warwickshire and Staffordshire represents its northern limit. The area includes the settlements of Curdworth, Lea Marston, Wishaw, Kingsbury and Middleton.

1.3.2 A location plan of the Proposed Scheme within this study area is shown on Figure 1.

Figure 1: Location plan



2 Flood risk assessment methodology

2.1 Source-pathway-receptor model

2.1.1 Flood risk is assessed using the source-pathway-receptor model. In this model, individual sources of flooding within the study area are identified. The primary source of flooding is rainfall, which is a direct source in the short term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewers) in the short or medium term. Stored rainfall, either naturally, in aquifers (groundwater) and natural lakes, or artificially in impounded reservoirs and canals can lead to flooding when the storage capacity of the system is exceeded. A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea. However, given the inland location of this study area, this source of flooding does not pose a risk.

2.1.2 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.

2.1.3 In general, receptors considered in this assessment include the Proposed Scheme and existing development within 1km of the route. However, any receptors beyond this where a significant impact was expected were considered in this assessment. The Proposed Scheme includes all associated temporary and permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified, mitigation is required as part of the design to prevent an increase in flood risk in line with recommendations in the NPPF.

2.1.4 The vulnerability of each receptor is classified using Table 2 of the NPPF Technical Guidance Document[2].

2.1.5 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the NPPF Technical Guidance Document and assesses whether the scheme has any potential to influence or alter the risk of flooding to each receptor. The Proposed Scheme will ensure that there is no adverse effect on the risk of flooding to third party receptors, and therefore, where such potential exists, mitigation is proposed based on further analysis.

2.1.6 The FRA defines the baseline flood risk and vulnerability of receptors. This is used to define the value, importance and significance of effects which is provided within the ES.

2.2 Flood risk categories

2.2.1 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

[2] Department for Communities and Local Government (2012), *National Planning Policy Framework Technical Guidance*.

Table 1: Flood risk category matrix for all flooding sources

Source of flooding	Flood risk category				
	No risk	**Low**	**Medium**	**High**	**Very high**
Watercourse[3]		Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3b
Surface water/ overland flow[4]	No FMfSW	FMfSW <0.3m for 1 in 200 year event	FMfSW >0.3m for 1 in 200 year event and FMfSW <0.3m for 1 in 30 year event	FMfSW >0.3m for 1 in 30 year event	
Groundwater[5]		Very low-low	Moderate	High-very high	
Drainage and sewer systems[6]	No sewer in vicinity of site	Surcharge point >20m from site and no pathways	Surcharge point within 20m of site and restricted pathways	Sewer network crosses site and pathways exist	
Artificial sources[7]	Outside of inundation mapping/no pathway exists	Within inundation mapping/pathway exists			

2.3 National planning policy framework

2.3.1 This assessment of flood risk makes use of the NPPF which is the Government's planning policy in relation to development and flood risk. It is set out within the NPPF that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. The NPPF requires that proposed development located within Flood Zones 2 and 3 is assessed in relation to flood risk. This includes both flood risk to the development and any increases in flood risk elsewhere as a result of the development, with an allowance for climate change.

2.3.2 Methods used to ensure that development is at the lowest possible risk and that the development is safe without causing an increased risk elsewhere includes the application of the Sequential and Exception Tests. However, the Sequential Test has been considered as part of the overview FRA for the Proposed Scheme presented in Volume 3 of the ES and hence has not been repeated in this FRA.

Flood zone classification

2.3.3 The NPPF splits the Environment Agency's Flood Map into three separate Flood Zones. These Flood Zones should be used in determining the appropriateness of

[3] River flood risk taken from the Environment Agency Flood Zone mapping or hydraulic modelling carried out for this FRA.
[4] Surface water flood risk taken from the Environment Agency Flood Maps for Surface Water (FMfSW).
[5] Groundwater flood risk taken from local flood risk assessment reports.
[6] Identified using the Severn Trent Water's and South Staffordshire Water assets network.
[7] Risk from reservoir flooding identified using the Environment Agency reservoir inundation mapping, canal flooding taken from identifying proximity of the Proposed Scheme to canals from Ordnance Survey mapping.

proposed development uses and they represent flooding without flood defences in place.

2.3.4 The Flood Zones are defined as:

- Flood Zone 1 – Areas with a 'low probability' of flooding and where the annual probability of flooding is lower than 0.1% for either river or sea flooding. The NPPF imposes no constraints upon the type of development within Flood Zone 1;
- Flood Zone 2 – Areas with a 'medium probability' of flooding and where the annual probability of flooding is between 0.1 and 1.0% for river flooding or between 0.5 and 0.1% for sea flooding. The NPPF recommends that Flood Zone 2 is suitable for most types of development with the exception of 'highly vulnerable' land uses; and
- Flood Zone 3 – Areas with a 'high probability' of flooding and where the annual probability of flooding is 1.0% or greater for river flooding or 0.5% or greater for sea flooding. The NPPF recommends that appropriate development is based upon a further classification of Flood Zone 3: 3a high probability and 3b functional floodplain (where water has to flow or be stored in times of flood).

2.4 Local flooding planning policy documents

2.4.1 The local policies for this study area with implication in relation to flood risk are:

- North Warwickshire Local Plan 2006[8] – ENV8 Water Resources. Policy ENV8 requires that water resources are safeguarded and enhanced and that development is protected from floodwater. In relation to flood risk this policy requires that the Sequential Test is applied when considering proposed development locations. In addition it requires that new development has satisfactory surface water drainage including the use of Sustainable Drainage Systems (SuDS) where appropriate and ensures access to watercourses for maintenance where required; and
- North Warwickshire Local Plan 2006 – ENV12 Urban Design. In relation to flood risk and water resources, policy ENV12 states that development will only be permitted if all the elements of the proposal are well related to each other and harmonise with both the immediate setting and wider surrounds to present a visually attractive environment. In addition, the existing natural features are treated as an integral part of the development.

2.4.2 The Warwickshire Strategic Flood Risk Assessment (SFRA)[9], the North Warwickshire SFRA[10] and Warwickshire Preliminary Flood Risk Assessment (PFRA)[11] aid the Council in preparing sustainable policies for the long-term management of flood risk and improving existing emergency planning procedures. The SFRA is used as an evidence base to promote the location of future development primarily in low flood risk areas.

[8] North Warwickshire Borough Council (2006), *North Warwickshire Local Plan*.
[9] Warwickshire County Council (2008), *Strategic Flood Risk Assessment. Volume 1* completed by Halcrow Group Ltd.
[10] North Warwickshire Borough Council (2008), *Strategic Flood Risk Assessment. Volume 1* completed by Halcrow Group Ltd.
[11] Warwickshire County Council (2011), *Warwickshire Preliminary Flood Risk Assessment*. Completed by Royal Haskoning on behalf of Warwickshire County Council.

The Warwickshire SFRA, the North Warwickshire SFRA and the Warwickshire PFRA have been used to inform this FRA.

2.5 Historical sources of flooding

2.5.1 The historical flooding which has occurred either at the location of the route or in close proximity have been determined as part of this FRA. These areas of historical flooding have been identified because places which have flooded in the past may be more susceptible to flooding in the future. Two sources of data relating to historical flooding have been used: local authority information (the relevant SFRA and PFRA) and extents of historical sources of river flooding as provided by the Environment Agency.

2.6 Flood risk approach

River flooding approach

Crossing locations

2.6.1 To determine the river flood risk at locations where the route will cross watercourses and to identify any changes in flood risk as a result of the Proposed Scheme, either existing hydraulic models have been used where available or new hydraulic models have been constructed. Where new models were required flows have been determined in line with current flood estimation guidelines[12].

Flow estimation

2.6.2 Existing hydraulic modelling was available to assess flood risk at the River Tame viaducts and the Curdworth viaduct through the use of the River Tame Hazard Mapping Study[13], and hence flows at these locations were taken from the existing River Tame model.

2.6.3 The other watercourses which will be crossed by the route within this study area have no known detailed modelling available. Where Flood Zones are associated with these watercourses, the outlines have been determined through the use of broadscale topographic data, which are considered to be a rough guide when determining areas at risk of flooding and hence have not be used for the design of engineering works. There are additional watercourses which have no associated Flood Zones. Flows for these watercourses with no existing modelling, at the location of the proposed crossings, have been determined for the 1 in 20 (5%), 1 in 100 (1%), 1 in 100 (1%) with a 20% allowance for climate change and 1 in 1000 (0.1%) annual probability events.

2.6.4 A quick estimation of flow was produced at the crossing locations using the Revitalised Flood Hydrograph model (ReFH) where the contributing catchments were represented within the Flood Estimation Handbook (FEH) CD-ROM[14]. A FEH calculation record for the estimation of flow using ReFH is provided in the river modelling report (Volume 5: Appendix WR-004-013).

[12] Environment Agency (2012), *Flood estimation guidelines*.
[13] Environment Agency (2009), *River Tame Hazard Mapping*. Completed by Halcrow on behalf of the Environment Agency.
[14] Centre for Ecology and Hydrology (2009), *FEH CD-ROM Version 3*, ©NERC (CEH).

2.6.5 Small catchments (normally less than approximately 0.5km^2), such as at the River Tame tributary, are not represented on the FEH CD-ROM and hence it is not possible to either produce a catchment boundary or determine catchment descriptors (required for the estimation of flow) from this source. For crossings where the watercourse is not represented within the FEH CD-ROM, a scaling method based on area, in line with the flood estimation guidelines was carried out. Contributing catchment areas at crossing locations were determined using topographic and Ordnance Survey (OS) mapping; in areas of uncertainty slightly larger catchments were defined as a conservative approach. The flows estimated through the use of ReFH for catchments in the northern study areas of the Proposed Scheme were used to determine a scaling factor. The greatest flow per km^2 was used as a scaling factor for the catchments in this study area which were manually determined. An error allowance of 10% was also applied to reduce the risk of underestimating flows.

Modelling approach

2.6.6 At river crossing locations where existing hydraulic models were available, and were in a suitable format for this assessment, these were used. Specifically, the River Tame Hazard Mapping Study model was used in this study area. This model was rerun for the baseline (current) scenario and for the Proposed Scheme scenario. At crossings where suitable models were not available new hydraulic models were built utilising the high resolution Light Detection and Ranging (LiDAR) data provided for the Proposed Scheme. Further detail in relation to the hydraulic modelling is included in the river modelling report, (Volume 5: Appendix WR-004-013).

2.6.7 There are several road embankments and raised infrastructure across the watercourses which will potentially provide constriction to flows. The modelled Digital Terrain Model (DTM) was modified to allow for flows through culverts underneath these embankments. In the absence of any survey data of these road embankment culverts, a channel opening of 5m was incorporated at each of these embankments.

2.6.8 The inflow boundaries were mostly applied as steady state flows with unsteady state flows applied for certain watercourses. For watercourses with floodplain attenuation such as ponds and lakes or significant obstructions to flow (e.g. road embankments), the inflows were modelled using unsteady state hydrographs. These models were run at longer durations covering the period of the hydrograph and attenuation. The resulting baseline (current) models were run for the 1 in 100 (1%) annual probability with an allowance climate change and 1 in 1000 (0.1%) events over a range of durations depending upon the flow conditions.

2.6.9 The Proposed Scheme models included either viaducts or culverts depending on the scheme design. The railway embankments were represented by modifying the modelled DTM at those locations. The 1 in 100 (1%) annual probability with an allowance for climate change peak flood levels upstream of the crossings were compared to the baseline (current) levels to assess the change in flood risk. The 1 in 1000 (0.1%) annual probability peak levels were extracted to inform the vertical alignment of the track.

River flood risk elsewhere along the route

2.6.10 In addition to watercourse crossings, there are sections of the route which are located in areas potentially at risk of river flooding. These areas have been identified through

the use of the Environment Agency Flood Zone mapping. This mapping has been used in preference to SFRA mapping as it is considered more up to date and hence likely to best reflect areas at risk. River flood risk to these sections of the route needs to be determined both to prevent an unacceptable risk to the Proposed Scheme and to prevent it increasing flood risk as result of a reduction in floodplain storage.

Summary of river flooding approach

2.6.11 Due to the number of river crossings, varying complexities, and the amount of data and information available for each, at some locations the modelling approach is highly specific. These locations have been reported as such and further information is included in the river modelling approach report (Volume 5: Appendix WR-004-013).

Surface water flood risk

2.6.12 The baseline (current) assessment of surface water flood risk was completed using the Flood Maps for Surface Water (FMfSW). The maps utilised for this assessment are listed as:

- 1 in 30 (3.3%) annual probability and surface water flooding greater than 0.1m deep;
- 1 in 30 (3.3%) annual probability and surface water flooding greater than 0.3m deep;
- 1 in 200 (0.5%) annual probability and surface water flooding greater than 0.1m deep; and
- 1 in 200 (0.5%) annual probability and surface water flooding greater than 0.3m deep.

2.6.13 This mapping identified sections of the route which currently are at specific risk from surface water flooding. The risk classification assigned at each location is dependent on which FMfSW the receptor is located within.

2.6.14 The Proposed Scheme has the potential to interrupt surface water flow which would require mitigation to prevent an increase in flood risk. In addition, other design elements such as landscaping will alter the permeability of the ground and hence modify sections of the surface water catchments. The assessment involved determining the land drainage catchments, surface water run-off from these catchments and the capacity of SuDS and culverts.

2.6.15 Land drainage catchments were identified using topographic data (primarily 5m contours, or 1m contours on small or unclear catchments). The assumption was made that linear features such as roads and railways do not act as a cut off for overland flow.

2.6.16 The calculation of greenfield run-off rates from existing catchments was undertaken using the online SuDS tool[15]. A growth factor of 30% was applied to the 1 in 100 (1%) annual probability rainfall event to determine the flow during this event with an allowance for climate change. A factor of 62% (based on calculations using the Flood

[15] HR Wallingford (2013), UK Sustainable Drainage Guidance and Tool. The Greenfield run-off estimation for sites tool. http://geoservergisweb2.hrwallingford.co.uk/uksd/greenfieldrun-off.aspx.

Studies Supplementary Report 14[16]) was applied to the 1 in 100 (1%) annual probability rainfall event to determine the flow during the 1 in 1000 (0.1%) annual probability event.

2.6.17 Run-off from modified sections of the catchment as a result of the Proposed Scheme (e.g. landscape areas) which alter the permeability was determined using the Institute of Hydrology 124[17] (IH124) methodology with a value of 0.5 for the soil parameter and a safety factor of 1.2.

2.6.18 Storage volumes were calculated using the SuDS calculator tool assuming that landscape areas will be impermeable. The storage volumes required were taken to be the sum of the attenuation and long term storage as a conservative approach.

2.6.19 The calculations for the proposed drainage design have been completed in line with the requirements in Volume 1, Section 9.14.

Groundwater flood risk

2.6.20 Groundwater bodies and aquifers present within a 1km buffer of the route have been identified and named on available web-based mapping data provided for the purposes of the Proposed Scheme.

2.6.21 Field investigations have not yet been undertaken due to limited access to land and the need to integrate investigative requirements from several disciplines.

Sewer systems flood risk

2.6.22 The risk of flooding from the sewer network has also been addressed in this FRA. The sewer network data was provided for this assessment by the relevant water company, Severn Trent Water, to determine locations of the route and other design elements which will be located at areas of risk.

Other sources of flood risk

2.6.23 Reservoir flood risk was assessed using the reservoir inundation maps as shown on Volume 5: Maps WR-01-033 and 034. The purpose was to identify areas along the route that were at risk of flooding if any reservoirs in the vicinity were to fail.

2.6.24 Canals have been identified as another source of potential flood risk, and so canals that will be crossed by certain sections of the route have been identified in the assessment.

[16] Institute of Hydrology (1983), *The Flood Studies Supplementary Report Number 14*.
[17] Institute of Hydrology (2004), *Report number 124, Flood Estimation for Small Catchments*.

3 Design criteria

3.1 Principal design criteria

3.1.1 The Proposed Scheme will provide a safe and reliable high speed rail link which will be compatible with the existing rail network and also HS1.

3.1.2 The Proposed Scheme will provide a 'passenger' only service and not 'freight' operation.

3.1.3 The design shall seek to ensure that any impacts as a result of its development will be designed out or minimised as far as practicably possible.

3.2 Flood risk design approach statement

3.2.1 The overall project seeks to ensure that there will be no increase in flood risk to any existing receptors as a result of the Proposed Scheme. This will be achieved by ensuring that overall flood storage capacity is maintained including an allowance for climate change.

3.2.2 In line with the NPPF technical guidance, increases in peak rainfall intensity and peak river flow of 20%, as a result of climate change, have been allowed for as per the period 2085 to 2115. This 20% increase has been used for the purposes of assessing flood risk. However, the hydraulic modelling involves sensitivity testing which includes a 20% increase, in addition to the 20% allowance for climate change.

3.2.3 All underbridge and viaduct crossings will be designed to allow the 1 in 100 (1%) annual probability flow (with allowance for climate change) to pass underneath. Upstream water levels will not be increased and a minimum of 600mm freeboard will be provided to the bridge soffits above this level which will allow for debris should flooding occur. On main rivers, where possible, a freeboard of 1m has been allowed.

3.2.4 Main river underbridges and viaducts will also accommodate river maintenance requirements and allow for a 5.3m vertical clearance above the floodplain ground level.

3.2.5 Culverts have been designed to convey the 1 in 100 (1%) annual probability flow (with allowance for climate change), with a freeboard of 300mm as a minimum applied for the culvert design. The design has also taken into account submerged inverts and the inclusion of mammal ledges.

3.2.6 River crossings will minimise any requirement for replacement floodplain storage areas.

3.2.7 The proposed rail infrastructure will be protected against inundation in the 1 in 1000 (0.1%) annual probability flood event. This will be achieved through ensuring a freeboard of 1m on the 1 in 1000 (0.1%) annual probability flood level. The railway drainage will be designed to have capacity up to the 1 in 100 (1%) annual probability peak rainfall event. However, the design will also ensure that the flood level does not exceed 1m below the track level during the 1 in 1000 (0.1%) annual probability rainfall event.

3.2.8 All drainage will be attenuated in order that peak surface water run-off from the proposed infrastructure is no greater than the existing current day baseline run-off under the 1 in 100 (1%) annual probability peak rainfall event.

3.2.9 All drainage will be designed to ensure that disruption to existing groundwater flood flows will be kept to a minimum, both during and following construction of the permanent works.

3.3 Cross drainage design approach statement

3.3.1 The drainage design will ensure that there is no increase in run-off to the receiving watercourse as a result of the Proposed Scheme.

3.3.2 Surface and ground water drainage shall be provided so as to ensure that water levels do not rise above a 1m freeboard below the rail level.

3.3.3 The route will be designed to ensure safe operation of trains during a 1 in 1000 (0.1%) annual probability event.

3.3.4 As part of the drainage design an allowance of 30% has been added to design events for climate change.

4 Data sources

4.1.1 Consistent with the requirements of the NPPF, this assessment considers the risk of flooding from rivers, overland flow (surface water), rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.

4.1.2 The route will lie entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.

4.1.3 The primary datasets for each source of flooding used to assess the design elements are:

- OS 1:10,000 mapping;
- topographic survey commissioned for the purposes for the Proposed Scheme (200mm grid resolution LiDAR survey, in DTM and digital surface model format);
- Environment Agency Flood Zone mapping and historic flood mapping;
- Environment Agency website for reservoir inundation mapping;
- North Warwickshire SFRA[10];
- Warwickshire SFRA[9];
- Warwickshire PFRA[11];
- Environment Agency national surface water flood mapping datasets specifically the Midlands FMfSW; and
- Severn Trent Water asset mapping.

4.1.4 A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the line, further investigation is undertaken, specifically hydraulic modelling for the areas at risk from river flooding.

5 The Proposed Scheme

5.1 Permanent works

5.1.1 The general design of the Proposed Scheme is described in Volume 2, Section 2.2. The following section describes the main features of the Proposed Scheme in this study area, which are specifically relevant for this FRA.

Overview

5.1.2 The route through the area will be approximately 8.6km in length. It will commence at the crossing of the River Tame (Volume 2: Map CT-06-112b, J6), east of Curdworth. It will then proceed north to the edge of the area where the route crosses Gallows Brook on viaduct (Volume 2: Map CT-06-116a, C6).

River Tame to Faraday Avenue

5.1.3 On leaving the Coleshill Junction area (CFA19), the route will continue northwards to cross the River Tame and the Birmingham and Derby railway on a group of viaducts and then onto embankment approximately to Faraday Avenue (Volume 2: Map CT-06-112b, E6).

5.1.4 Key features of this section, which have been assessed in this FRA, will include:

- four viaducts, which are the Curdworth viaduct and the three River Tame viaducts (River Tame east and west viaducts and Water Orton no. 2 viaduct), approximately 550m long, over the River Tame, Water Orton Sewage Works, the Minworth Effluent Channel and Birmingham and Derby railway; and
- a balancing pond will be provided to the west of the route just north of the Birmingham and Derby railway crossing (Volume 2: Map CT-06-112b, G7) and another just to the north of Faraday Avenue (Volume 2: Map CT-06-112b, E6).

Faraday Avenue to the M42 crossing

5.1.5 Continuing to the north, the route will pass into a substantial cutting, across the realigned Kingsbury Road and then onto an embankment and on a box structure over the M42.

5.1.6 Key features of this next section, which have been assessed in this FRA, will include:

- an approximately 1.3km long cutting (Curdworth cutting) with an approximate depth of 15m for the main line and 22m for the northbound Leeds spur. At its widest, the cutting will be approximately 190m wide, just north of the A4097 Kingsbury Road; and
- a balancing pond will be provided to the north-east of Seeneys Lane (Volume 2: Map CT-06-113-R1, E5).

M42 crossing to east of Hunts Green

5.1.7 Continuing to the north the route will pass over the M42 and Birmingham and Fazeley Canal to the east of Cuttle Mill Fishery, then under Bodymoor Heath Lane. Key features of this next section, which have been assessed in this FRA, will include:

- the Birmingham and Fazeley Canal viaduct;
- the Cuttle Mill underbridge immediately to the east of Cuttle Mill Fishery;
- an approximately 4m high combined underbridge over a watercourse and access track (North Wood underbridge) at the floodplain north of North Wood; and
- an approximately 4m high underbridge (Hunts Green underbridge) at the floodplain just south of Bodymoor Heath Lane; and
- Four balancing ponds (Volume 2: Map CT-06-113 and CT-06-114).

East of Hunts Green to Gallows Brook

5.1.8 Continuing to the north-west, the route will alternate between cutting and embankment, passing to the east of Hunts Green before reaching the northern extent of the area at the viaduct crossing of Gallows Brook. Key features of this next section, which have been assessed in this FRA, will include:

- an approximately 90m long viaduct over Langley Brook (Volume 2: Map CT-06-115);
- an approximately 430m long cutting (Coppice Lane cutting) with an average depth of 2m;
- a 1.1km long embankment (Trickley Coppice embankment) of varying height extending to Gallows Brook. Gallows Brook will be culverted below the railway embankment (Volume 2: Map CT-06-116a, G6);
- the a viaduct over the tributary of the Tame, at the Drayton Bassett viaduct (Volume 2: Map CT-06-116a, C6) at the northern extent of CFA20; and
- two balancing ponds will be constructed in this section which will connect to a drainage system established along the side of the route, connecting to outfalls at Langley Brook.

5.1.9 The route will then continue across the Drayton Bassett viaduct into the Drayton Bassett, Hints and Weeford area (CFA21).

5.2 Temporary works

5.2.1 All contractors will be required to comply with the environmental management regime for the Proposed Scheme, which will include:

- Code of Construction Practice (CoCP); and
- Local Environmental Management Plans (LEMP).

5.2.2 The key requirements of the draft CoCP in relation to flood risk are:

- making appropriate use of the Environment Agency's flood warning service;
- preparing site specific flood risk management plans for temporary works at risk of flooding from river, surface water and groundwater sources;

- considering flood risk when planning temporary sites and storing materials;
- obtaining consent, as required, for works affecting a watercourse;
- removing or stopping and sealing of drains and sewers taken out of use;
- not discharging site run-off to ditches, watercourses, drains or soakaways without agreement of the appropriate authority;
- ensuring hoarding and fencing in areas at risk of flooding will be permeable to floodwater, unless otherwise agreed with the Environment Agency or Warwickshire County Council (the Local Lead Flood Authority in this study area); and
- implementing precautions to be taken to prevent damage to services and to avoid pollution during service diversions, excavations and ground penetration.

5.2.3 The temporary works will include both main and satellite construction compounds. These compounds will be utilised for office accommodation, local storage for plant and materials, car parking, material processing facilities and welfare facilities.

5.2.4 Areas adjacent to these compounds may be used for temporary storage of topsoil stripped as part of the works.

5.2.5 Temporary worker accommodation will also be required for the Proposed Scheme.

6 Existing flood risk

6.1.1 Through the use of the Environment Agency historical flood maps, there are no areas of historical flooding that will be either crossed by the route or will be within 1km of the route.

6.1.2 The Warwickshire SFRA[9] historical flood maps indicate that there have been no incidents of flooding either at the location of the route or within 1km of the route centreline. This includes flood events from rivers, surface water, artificial sources, canals or unknown sources.

6.1.3 The Warwickshire PRFA[11] has also been used to identify potential locations of flooding in the vicinity of the route. This mapping indicates that historical events have occurred in the along Langley Brook in the vicinity of the proposed crossing. A number of these events have been classed as exceptional with property flooding, and other events have been classed as occurring every 1 to 5 years with no property flooding.

6.2 River flooding

6.2.1 River flood risk is the risk of flooding posed by rivers and streams. The risk in CFA20 is from the River Tame and its tributaries, Langley Brook and its tributaries, and Gallows Brook. The areas at risk of flooding from this source are shown in Volume 5: Maps WR-05 and WR-06.

6.2.2 The assessment of baseline (current) flood risk involved identifying watercourse crossings and the associated risk through the use of the Environment Agency Flood Zones. The results of this assessment are provided in Table 2. The watercourse identifier references have been taken from Volume 5: Maps WR-01-033 and 034. The River Tame viaducts, as listed in Table 2, are the River Tame east and west viaducts and the Water Orton no. 2 viaduct.

Table 2: Curdworth to Middleton river flood risk

Watercourse identifier and map reference	Crossing name	Watercourse	1 in 100 (1%) + climate change flow	Risk level	Receptor vulnerability
SWC-CFA20-001 Volume 5: Map WR-01-033, G6	River Tame viaducts	Main river (River Tame)	210.74m^3/s	Very high	Less vulnerable
SWC-CFA20-002 Volume 5: Map WR-01-033, G6	Curdworth viaduct	Ordinary watercourse (tributary of the River Tame)	5.42m^3/s	Very high	Less vulnerable
SWC-CFA20-003 Volume 5: Map WR-01-033, G6	Curdworth viaduct	Ordinary watercourse (tributary of the River Tame)	0.38m^3/s	Very high	Less vulnerable
SWC-CFA20-004 Volume 5: Map WR-01-033, G6	Curdworth viaduct	Ordinary watercourse (tributary of the River Tame)	Not calculated	Very high	Less vulnerable
No watercourse ID. Located adjacent to Faraday Avenue Volume 5: Map WR-01-033, F6	Faraday Avenue underbridge	Ordinary watercourse (unknown discharge location)	Not calculated	Very high	Less vulnerable

Watercourse identifier and map reference	Crossing name	Watercourse	1 in 100 (1%) + climate change flow	Risk level	Receptor vulnerability
SWC-CFA20-005 Volume 5: Map WR-01-033, F6	Faraday Avenue underbridge	Ordinary watercourse (unknown discharge location)	Not calculated	Very high	Less vulnerable
SWC-CFA20-009 Volume 5: Map WR-01-033, C5	Cuttle Mill underbridge	Ordinary watercourse (tributary of Langley Brook)	1.50m^3/s	Very high	More vulnerable
SWC-CFA20-010 Volume 5: Map WR-01-034, F6	North Wood north culvert	Ordinary watercourse (tributary of Langley Brook)	4.96m^3/s	Very high	Less vulnerable
SWC-CFA20-011 Volume 5: Map WR-01-034, F6	Hunts Green underbridge	Ordinary watercourse (tributary of Langley Brook)	2.64m^3/s	Very high	Less vulnerable
SWC-CFA20-013 Volume 5: Map WR-01-034, D5	Langley Brook viaduct	Ordinary watercourse (Langley Brook)	14.24m^3/s	Very high	Less vulnerable
SWC-CFA20-014 Volume 5: Map WR-01-034, C6	Gallows Brook culvert	Ordinary watercourse (Gallows Brook)	0.97m^3/s	Very high	Less vulnerable
SWC-CFA20-015 Volume 5: Map WR-01-034, B6	Drayton Bassett viaduct	Ordinary watercourse (tributary of the River Tame)	2.35m^3/s	Very high	Less vulnerable

6.2.3 The Environment Agency Flood Zone mapping indicates five main areas at risk from flooding:

- the southern extent of the study area at the location of River Tame viaducts and Curdworth viaduct (Volume 5: Map WR-01-033, G6);
- at the Cuttle Mill underbridge (Volume 5: Map WR-01-033, C5);
- to the north and south of Middleton House Farm (Volume 5: Map WR-01-034, F6);
- at Langley Brook viaduct (Volume 5: Map WR-01-034, D5); and
- in the vicinity of Drayton Bassett viaduct (Volume 5: Map WR-01-034, B6).

6.2.4 The crossing locations are identified to fall within Flood Zone 3. However, given that the route will cross the watercourse, they will also be located within Flood Zone 3b (very high risk).

6.2.5 The Environment Agency flood mapping covers watercourses with catchments greater than 0.5km^2, and hence small catchments are often not represented. This includes Gallows Brook (SWC-CFA20-014) at the location of the Proposed Scheme.

6.2.6 Hydraulic modelling was carried out to provide a more accurate representation of river flood risk along the route, specifically at locations where the route will cross a watercourse. The modelling provided flood extents for the 1 in 100 (1%) annual probability event with a 20% allowance for climate change and for the 1 in 20 (5%) annual probability event. Flood levels were also determined for the 1 in 1000 (0.1%) annual probability event to ensure that the proposed track will not be at risk during

this event. The flood extents and levels as determined through hydraulic modelling are detailed in the river modelling appendix (Volume 5: Appendix WR-004-013).

6.2.7 The Environment Agency flood mapping indicates that the Gallows Brook culvert is located within Flood Zone 1. However, following hydraulic modelling completed for this assessment it is redefined as Flood Zone 3b. Therefore the risk classification given to this location is very high.

6.2.8 At the northern extent of the proposed Curdworth viaduct, approximately 400m to the south of Faraday Avenue the route will cross a minor drain (SWC-CFA20-004). The proposed drainage channel will be located adjacent to this drain. Given the clearance required for the railway, the viaduct will not have an impact on flow at this location. Therefore flood risk associated with this watercourse is not considered further.

6.2.9 The two watercourses (SWC-CFA20-005 and a drain to the south) crossed by the Faraday Avenue underbridge have not been hydraulically modelled. These watercourses are considered minor drains located adjacent to an existing road (Faraday Avenue), with little to no associated natural catchment. It is proposed that the development at this location will accommodate road drainage and hence the loss of these drains is not considered to impact on flood risk. Therefore these two drains have not been considered further.

6.2.10 The vulnerability classification as shown in Table 2 above has been taken from the NPPF and relates to the vulnerability of existing development in areas currently at risk from river flooding. At the location of Mill Pool (upstream of the proposed Cuttle Mill underbridge) a more vulnerable classification has been assigned because there are buildings located within the floodplain, which potentially could be residential. Upstream of the Langley Brook viaduct, there is a sewage treatment works which is adjacent to the flood extent. This existing development, and other land uses at risk from river flooding are classed as less vulnerable in line with NPPF. At the other crossings, a less vulnerable classification has been assigned because the land use is agricultural.

6.2.11 The other locations along the route not identified in Table 2 are considered to be at either a low risk or no risk of river flooding.

6.3 Surface water/overland flow

6.3.1 This section is an examination of the existing flood risk posed by rainfall falling on the ground surface, referred to as surface water flooding. It is examined in terms of the water flowing over the ground surface that has not entered a natural drainage channel or artificial drainage system.

6.3.2 The areas at risk from surface water flooding are shown on Volume 5: Maps WR-01-033 and 034. Table 3 details the risk to the development from this source of flooding.

Table 3: Curdworth to Middleton sources of surface water flooding

Description of surface water flooding location	Description of possible influence to the Proposed Scheme	Risk
North of the River Tame and Water Orton Volume 5: Map WR-01-033, G5	The route will cross small areas at risk from surface water flooding. The areas are generally at low and medium risk, although there are isolated areas at a high risk.	High
North of Faraday Avenue Volume 5: Map WR-01-033, F6	An area on western edge of the route will cross an area at high risk of surface water flooding.	High
East of Junction 7 on the M42 Volume 5: Map WR-01-033, E6	Various small isolated areas susceptible to surface water flood risk are identified within 100m of the route to the east and west of the route. These areas are categorised at low and medium risk.	Medium
M42 crossing and Cuttle Mill Fishery Volume 5: Map WR-01-033, D5	The route will cross three main areas at risk from surface water flooding. These are categorised at a low, medium and high risk.	High
West of Bodymoor Heath Volume 5: Map WR-01-034, F6	The route will cross large areas at risk from surface water flooding which are predominately classed as at a low and medium risk. However, there are small isolated areas that are adjacent to the route, which are classed as high risk.	High
Langley Brook, east of Middleton Volume 5: Map WR-01-034, D5	The route will cross large areas at high risk of surface water flooding, although this area is considered to represent the Langley Brook floodplain.	High
Gallows Brook, north of Middleton Volume 5: Map WR-01-034, C6	The route will cross an area at risk from surface water flooding which is predominately categorised as medium risk, although areas at high risk are also crossed at this location.	High
In the vicinity of the Drayton Bassett viaduct Volume 5: Map WR-01-034, B6	The route crosses areas susceptible to surface water flooding which are associated with the watercourses (CFA21-SW-054) at this location. These areas are categorised as being at a low and medium risk of surface water flooding.	Medium

6.3.3 There are eight locations along the route in this study area which have been identified to be at risk from surface water flooding from the Environment Agency FMfSW. At the majority of these locations the risk of surface water flooding ranges from low to high. However, as a conservative approach the highest level of risk has been assigned. Therefore at six locations the risk is considered high and at two locations the risk is considered medium.

6.3.4 In line with the risk category matrix provided in Table 1, and the data available for this FRA, all other locations along the route within this study area are classed to be at no risk from surface water flooding.

6.4 Groundwater

6.4.1 Groundwater flood risk has been qualitatively assessed based on hazard identification and evaluation using the conceptual understanding of the ground conditions at the location of the Proposed Scheme. The assessment of the current groundwater flood risk is based on the presence or otherwise of an aquifer and the relative depth of groundwater level, as well as historical information on the occurrence of groundwater flooding incidents.

6.4.2 The SFRA[16] and PFRA[17] for the area do not record and particular areas of substantiated groundwater flooding. Therefore it is concluded that the risk from groundwater flooding is low.

6.5 Sewer systems

6.5.1 Sewer infrastructure is a potential source of flood risk in the event of a failure. Due to the nature of the closed sewer system, sewer flooding will only be caused if there is a blockage or a leak or if there is a rainfall event greater than the design capacity of the network.

6.5.2 The risk to the route from the sewer network has been determined based on the location of the route in relation to these networks and the proximity and potential flow paths from inspection covers. Flow paths have been assessed through the use of LiDAR and OS mapping.

6.5.3 One location has been identified to be at a potential risk from the sewer network. At Volume 5: Map WR-01-034, D6, the route will be located approximately 80m from an inspection cover; however the topography suggests that there is no flow path to the Proposed Scheme. Therefore the risk from the sewer network at this location is low.

6.6 Artificial sources

6.6.1 Artificial sources of flood risk describe a mechanism whereby flooding would be the result of failure of infrastructure that impounds water such as a canal or reservoir.

6.6.2 There is one canal which will be crossed by the route in this study area. This is the Birmingham and Fazeley Canal (SWC-CFA20-006) which is crossed by the Birmingham and Fazeley Canal viaduct, to the south of Cuttle Mill Fishery. Through the use of LiDAR data it has been determined that the canal, at the location of the crossing, is not raised above surrounding ground level and hence there is no risk of structural breaching when the water level is maintained at the design level. However, there is a small embankment which could be over topped if water levels rise above the design level. In this event water will spill to the north and away from the Proposed Scheme.

6.6.3 Water levels within canals are maintained and therefore it is unlikely that overtopping would occur. In line with the risk category matrix in Table 1 the risk of flooding from this source is considered low.

6.6.4 The Environment Agency reservoir inundation mapping identifies that the southern boundary of this study area will be inundated if either Rotton Park (also known as Edgbaston Reservoir) or Bartley reservoirs fail. These reservoirs are located at least 15km upstream of the Proposed Scheme and it is considered that flood water would be of low velocity and likely to be a low hazard at the location of the Proposed Scheme. In addition, the reservoir inundation extent at this location is narrower than the widths of Flood Zones 2 and 3 and therefore the risk from reservoir flooding is considered to be less than the risk of river flooding at this location.

6.6.5 The reservoir inundation mapping shows that the area to the north of Middleton House Farm is located in areas a risk of flooding following reservoir failure. This area is at risk should Belfry Reservoir fail. This reservoir is located over 1km upstream of the

Proposed Scheme and flood water would have to flow via three road bridges (that would act as a constriction to flow) prior to reaching the Proposed Scheme. It is therefore considered that flood water, as a result of reservoir breaching, would be of low velocity and hence low hazard at the location of the Proposed Scheme. At the location where the route will cross the watercourse, which is likely to act as the flow path for reservoir flooding, the inundation extent is of a similar width as Flood Zones 2 and 3. However, to the north of Bodymoor Heath Lane the reservoir inundation mapping covers a greater extent than the river Flood Zone mapping.

6.6.6 The reservoir inundation mapping extends slightly into this study area along the northern boundary. This area is at risk should Canwell Estate Reservoir fail. This reservoir is located over 2km upstream of the northern boundary of the study area and the extent at risk, as shown on the reservoir inundation mapping, is similar to that of Flood Zones 2 and 3.

6.6.7 Due to the strict regulations and high maintenance associated with reservoirs, breaching is considered unlikely. In line with the risk category matrix in Table 1 the risk of flooding from this source is considered low.

6.6.8 In addition to the designated reservoirs which have been assessed as part of the Environment Agency reservoir inundation mapping, the route is at risk should the impounded water body at Cuttle Mill Fishery fail. It is anticipated that if this water body fails, flood water would follow the watercourse at this location and hence under the Cuttle Mill viaduct. Given that the route will be situated on a viaduct at this location, the risk to the route is considered low.

6.7 Summary

6.7.1 The Proposed Scheme will cross 12 watercourses and therefore it is concluded that the Proposed Scheme will be within areas that are classified as being potentially at a very high risk from river flooding in this study area. The land use at in the vicinity of the Cuttle Mill underbridge is potentially residential and hence a more vulnerable classification has been assigned. Elsewhere, the only land uses at risk in this study area (which could be impacted as result of the Proposed Scheme) are classed as less vulnerable.

6.7.2 There are eight locations along the route which have been identified to be at risk from surface water flooding. The risk at these locations generally range from low to high, although as a conservative approach the highest level of risk has been assigned. Therefore six locations have been categorised as at a high risk and two locations at a medium risk.

6.7.3 The risk of groundwater flooding has been assessed as low as no substantiated instances of groundwater flooding have been reported.

6.7.4 At one location a sewer network inspection cover is located within 80m of the route although the topography of the area indicates that there are no known flow paths to the route. Therefore the Proposed Scheme is at a low risk of flooding from sewer networks.

6.7.5 Water levels within canals are continually maintained and hence the chance of overtopping or breaching when water levels raise above the design level and thus

flood risk from this source is considered low. Similarly due to the strict monitoring and maintenance requirements, the risk of reservoir flooding to the Proposed Scheme is considered low.

7 Flood risk management measures

7.1 River flood risk

Flood risk to proposed scheme

7.1.1 The Proposed Scheme will be raised above the 1 in 1000 (0.1%) annual probability flood level at floodplain crossings. Therefore, the mitigation measures included in the design have ensured that there are no instances where the Proposed Scheme would be at significant risk of river flooding, and consequently no specific mitigation is required.

Impact of proposed scheme

7.1.2 At all floodplain crossings, areas for replacement floodplain storage are included in the design upstream of the Proposed Scheme for losses in floodplain storage, including viaduct piers, embankments and all associated development.

North Wood north culvert

7.1.3 Hydraulic modelling at this location suggests that the Proposed Scheme will result in an afflux of up to 41mm, extending to a maximum distance of 140m upstream of the North Wood north culvert during the 1 in 100 (1%) annual probability event with an allowance for climate change. This change in flood level causes a minor impact which will be reduced through the incorporation of replacement floodplain storage.

Hunts Green underbridge

7.1.4 Hydraulic modelling at this location suggests that the Proposed Scheme will result in an afflux of up to 96mm, extending to a maximum distance of 174m upstream of the Hunts Green underbridge during the 1 in 100 (1%) annual probability event with an allowance for climate change. This change in flood level causes a moderate impact which will be reduced through the incorporation of replacement floodplain storage.

Langley Brook viaduct

7.1.5 Hydraulic modelling at this location suggests that the Proposed Scheme will result in an afflux of up to 37mm, extending to a maximum distance of 17m upstream of the Langley Brook viaduct during the 1 in 100 (1%) annual probability event with an allowance for climate change. This change in flood level causes a minor impact which will be reduced through the incorporation of replacement floodplain storage.

Other watercourse crossings

7.1.6 The hydraulic modelling for the other six watercourse crossings in this study area has shown that the Proposed Scheme will have a negligible impact on river flood risk. Areas of land have been identified as suitable to provide replacement floodplain storage, therefore reducing the impact. Any replacement floodplain storage at the locations of negligible impact is likely to provide betterment.

Mitigation for temporary works

7.1.7 The temporary works have the potential to result in an increased river flood risk and be at risk of flooding from this source. The proposed mitigation and measures to prevent an unacceptable risk of river flooding for the temporary works includes

signing up to the Environment Agency flood warning system for the "Middle Tame – Low-lying land and roads between Water Orton and Tamworth including the Bourne Brook at Fazeley". Any temporary crossings will be designed to prevent an increased flood risk through ensuring sufficient capacity during the 1 in 100 (1%) annual probability event; an indication of the flows which will be considered are included in Table 2.

7.2 Surface water flood risk

Flood risk to Proposed Scheme

7.2.1 In this study area, areas categorised as being at a high risk of surface water flooding are generally associated with the watercourses identified in the river flooding sections in this report. At these locations the scheme design will ensure that the track is situated above the 1 in 1000 (0.1%) annual probability event flood level with a 1m freeboard. Therefore as long as there is no blockage of these structures, a low surface water flood risk to the track is anticipated at these locations.

7.2.2 At the one location where the route potentially crosses surface water flow paths, the drainage system will direct surface water flow away from the Proposed Scheme. Therefore, as long as the collection systems and surface water culverts are designed with sufficient capacity, there should be no backing up, and no expected risk of flooding to the Proposed Scheme.

Impact of Proposed Scheme

7.2.3 Potential increases in peak discharge rates of surface water run-off will be attenuated prior to discharging to the receiving watercourse. Any additional surface water to be discharged will be at a trickle rate to prevent exceeding the current capacity of the receiving watercourse.

7.3 Risk of flooding from groundwater

Flood risk to Proposed Scheme

7.3.1 The risk from groundwater flooding to the Proposed Scheme has been assessed as low and therefore no specific management measures are considered necessary.

Impact of the Proposed Scheme

7.3.2 The Proposed Scheme is not anticipated to have an impact on groundwater flooding and therefore no specific management is considered necessary.

7.4 Risk of flooding from sewer systems

7.4.1 There will be a low risk of flooding from sewer systems to the Proposed Scheme, and there are no anticipated effects on the risks of flooding from drainage systems within the study area arising from the Proposed Scheme. Therefore, no specific mitigation would be required.

7.5 Risk of flooding from artificial sources

Flood risk to Proposed Scheme

7.5.1 There are no instances where the Proposed Scheme would be at significant risk of flooding from artificial sources, and consequently no specific mitigation is required.

Impact of the Proposed Scheme

7.5.2 The Proposed Scheme in this study area is at risk of flooding resulting from the complete failure of four designated reservoirs. There is also one location where an additional impounded water body poses a potential flood risk to the Proposed Scheme. However, the replacement floodplain storage provided to mitigate the potential effects of river flooding would serve to either fully or partially offset any potential effects of the Proposed Scheme on flooding from this source. Due to the low probability of such flooding occurring, and the likely low significance of any impacts arising from the Proposed Scheme, it is not considered appropriate to provide additional mitigation for this scenario.

8 Post development flood risk assessment

8.1 River flooding

8.1.1 The key design elements of the Proposed Scheme with potential flood risk considerations have been modelled for this FRA. The modelling methodology and results specific for each watercourse crossing are included in the river modelling report (Volume 5: Appendix WR-004-013). A summary of the results are presented in Table 4. The watercourse identifier references have been taken from Volume 5, Maps WR-01-033 and 034.

Table 4: Curdworth to Middleton river flood risk

Watercourse identifier and map reference	Crossing name	1 in 100 (1%) + climate change flow	Change in flood level 1 in 100 (1%) +climate change	Change in flood level 1 in 1000 (0.1%)	Proposed Scheme 1 in 1000 (0.1%) level	Length of impacted upstream reach[18]
SWC-CFA20-001 Volume 5:, Map WR-05-056, H6	River Tame viaducts	210.74m^3/s	0mm	0mm	75.543mAOD	0m
SWC-CFA20-002 Volume 5: Map WR-05-056, G6	Curdworth viaduct	5.42m^3/s	0mm	2mm	75.600mAOD	0m
SWC-CFA20-003 Volume 5: Map WR-05-056, G6	Curdworth viaduct	0.38m^3/s	0mm	2mm	75.600mAOD	0m
SWC-CFA20-009 Volume 5: Map WR-05-057, F5	Cuttle Mill underbridge	1.50m^3/s	-11mm	54mm	72.670mAOD	0m
SWC-CFA20-010 Volume 5: Map WR-05-057, D6	North Wood north culvert	4.96m^3/s	41mm	98mm	69.347mAOD	140m
SWC-CFA20-011 Volume 5: Map WR-05-057, C6	Hunts Green underbridge	2.64m^3/s	96mm	174mm	69.035mAOD	135m
SWC-CFA20-013 Volume 5: Map WR-05-058, F6	Langley Brook viaduct	14.24m^3/s	37mm	17mm	71.876mAOD	124m
SWC-CFA20-014 Volume 5: Map WR-05-058, C6	Gallows Brook culvert	0.97m^3/s	0mm	-12mm	78.807mAOD	<20m
SWC-CFA20-015 Volume 5: Map WR-05-058, B7	Drayton Bassett viaduct	2.35m^3/s	0mm	0mm	85.810mAOD	0m

8.1.2 The hydraulic modelling indicates that at six of the eight crossing structures modelled, the Proposed Scheme will have a negligible impact on flood levels during both the 1 in 100 (1%) annual probability with an allowance for climate change and 1 in 1000 (0.1%) annual probability events. The results shown for Cuttle Mill underbridge and Drayton Bassett viaduct are for smaller culverts than will be constructed as part of the

[18] Length of reach upstream of the Proposed Scheme along which flood levels during the 1 in 100 (1%) annual probability+ climate change are greater than 10mm.

Proposed Scheme, and hence present a conservative approach to assessing flood risk at these locations.

8.1.3 The hydraulic modelling for North Wood north culvert, to the south of Middleton House Farm (SWC-CFA20-010), has indicated that without mitigation the Proposed Scheme will result in minor impact on flood levels during the 1 in 100 (1%) annual probability event with an allowance for climate change. However, hydraulic modelling has indicated that replacement floodplain storage can be provided upstream of this crossing to reduce change to a negligible impact. The impact downstream of the structure (not included in Table 4) is up to 15mm and limited to a 47m downstream reach.

8.1.4 The hydraulic modelling for Hunts Green underbridge indicates that the Proposed Scheme, specifically the encroachment of the Bodymoor Heath Lane realignment into the floodplain, will result in a moderate impact on flood level during the 1 in 100 (1%) annual probability with an allowance for climate change event. However, the hydraulic modelling has shown that mitigation (replacement floodplain storage) can be provided upstream of this crossing to reduce change to a negligible impact. The impact downstream of the structure (not included in Table 4) is up to 90mm and limited to a 166m downstream reach.

8.1.5 The hydraulic modelling at the Langley Brook viaduct indicates that the Proposed Scheme would have a minor impact on flood levels during the 1 in 100 (1%) annual probability event with an allowance for climate change. However, hydraulic modelling has indicated that replacement floodplain storage can be provided upstream of this crossing to reduce change to a negligible impact. The impact downstream of the structure (not included in Table 4) is up to 16mm and limited to a 30m downstream reach.

8.1.6 Watercourses pose a river flood risk to the other design elements in this study area. The areas at risk from river flooding are shown on Volume 5: Maps WR-05-056 to 058 and WR-06-056 to 058 and are based on the hydraulic modelling results rather than Environment Agency Flood Zone mapping. The river flood risks to these works are included in Table 5.

Table 5: River flood risks to the other design elements

Works at risk	Watercourse identifier and map reference	Location description	Description of the works and flood risk	Risk
Highways Earthworks Landscaping	SWC-CFA20-003 Volume 5: Map WR-05-056, G6	Access road from Lichfield Road, north of the River Tame	An access road and landscaping works will encroach in to the areas is identified to be at risk during the 1 in 20 (5%) annual probability event. The earthworks for the Faraday Avenue Embankment will be located adjacent to a watercourse (SWC-CFA20-003) at this location.	Very high
Landscaping Earthworks Other	SWC-CFA20-010 Volume 5: Map WR-05-057, D6	South of Middleton House Farm	Landscaping and earthworks will be located in areas is identified to be at risk during the 1 in 20 (5%) annual probability event. An underbridge is also located at this location.	Very high

Works at risk	Watercourse identifier and map reference	Location description	Description of the works and flood risk	Risk
Highways Landscaping Earthworks	SWC-CFA20-011 Volume 5: Map WR-05-057, C6	North of Middleton House Farm	The proposed Bodymoor Heath Lane realignment, the associated embankment and road bridge; and landscaping will encroach into areas is identified to be at risk during the 1 in 20 (5%) annual probability event.	Very high
Highways	SWC-CFA20-013 Volume 5: Map WR-05-058, F6	Langley Brook viaduct	Downstream of the proposed Langley Brook viaduct are the proposed works to the A4091 including the works to lengthen and include mammal ledges in the culvert, road embankments and associated landscaping. These works will cross the watercourse and hence are at a very high risk from this source.	Very high
Landscaping	SWC-CFA20-014 Volume 5: Map WR-05-058, C6	Gallows Brook	Various landscaping works will be located adjacent to the northern and southern banks of Gallows Brook. Therefore a high risk has been categorised at this location.	High

8.1.7 The proposed access from Lichfield Road will be located in areas at risk of river flooding. However, this road will not be elevated about the existing levels and hence it is considered to have an insignificant impact on river flood risk.

8.1.8 The realignment of Bodymoor Heath Lane and the associated embankments have been incorporated in the hydraulic modelling for the watercourse at this location (SWC-CFA20-011). The modelling indicates that the works will have a moderate impact on flood levels at this location during the 1 in 100 (1%) annual probability event with an allowance for climate change. However, the modelling has shown that mitigation can be provided upstream of this crossing to reduce change to a negligible impact.

8.1.9 The hydraulic modelling for works at Langley Brook assumes that the A4091 Tamworth Road culvert (located approximately 200m downstream of the Langley Brook viaduct) will act as a constriction to flow and that there will be a negligible impact on flood levels during the 1 in 100 (1%) annual probability event with an allowance for climate change. Therefore the road embankment works at this location will have a negligible impact on river flood risk.

8.1.10 In addition to the road culverts outlined in Table 5, there are further culverts proposed in this study area. However, these culverts are required for the surface water drainage system which forms part of the Proposed Works, rather than for existing watercourses. The capacity requirements for these culverts are addressed as part of the drainage design.

8.1.11 Temporary works as required for the construction phase are also located in areas at risk from river flooding. The temporary works at risk are listed in Table 6.

Table 6: River flood risk to temporary works

Watercourse identifier and map reference	Receptor	Comment	Risk
SWC-CFA20-001 Volume 5: Map WR-05-056, H6	Main river (River Tame)	The River Tame viaducts satellite compound (south) and temporary fencing are proposed in areas at risk during the 1 in 100 (1%) annual probability event with an allowance for climate change.	High
SWC-CFA20-009 Volume 5: Map WR-05-057, F5	Ordinary watercourse (tributary of Langley Brook)	A temporary bridge will cross the outfall from the water body at Cuttle Mill Fishery. Temporary site access/haul road and fencing will also be located in the area at risk during the 1 in 20 (5%) annual probability event.	Very high
SWC-CFA20-010 and 011 Volume 5: Map WR-05-057, D6 and C6	Two ordinary watercourses (tributaries of Langley Brook)	Two temporary bridges will cross two separate tributaries of Langley Brook. Temporary site access/haul road and fencing will also be located in the area at risk during the 1 in 20 (5%) annual probability event.	Very high
SWC-CFA20-013 Volume 5: Map WR-05-058, F6	Ordinary watercourse (Langley Brook)	A temporary bridge will cross Langley Brook and temporary site access/haul road and fencing will also be located in the area at risk during the 1 in 20 (5%) annual probability event.	Very high
SWC-CFA20-014 Volume 5: Map WR-05-058, C6	Ordinary watercourse (Gallows Brook)	A temporary bridge will cross Langley Brook and site access/haul road will be located on both sides of this watercourse.	Very high
SWC-CFA20-015 Volume 5: Map WR-05-058, B7	Drayton Bassett viaduct	A temporary plant crossing, a site access/haul road and temporary fencing will be required in the areas at risk of flooding from this watercourse. These areas at risk will be in the area at risk during the 1 in 20 (5%) annual probability event.	Very high

8.1.12 There are six locations of temporary works that are located in areas at risk from river flooding. The areas at risk have been identified through the hydraulic modelling completed for this assessment.

8.1.13 Hydraulic modelling is not considered necessary for the temporary works because the works will be constructed in line with the CoCP (Section 16 of the draft CoCP) and thus the design will consider river flood risk. Therefore temporary works will not result in an increased flood risk to any existing receptors.

8.1.14 The hoarding and fencing around a site for security purposes has the potential to alter flow paths and thus impact on flood risk at the three locations identified in Table 6. However, the hoarding and fencing in areas at risk of flooding will be permeable to floodwater, (as outline in the design criteria in Section 0 of this report), unless otherwise discussed with the Environment Agency or Local Lead Flood Authority. This will ensure that the floodplain continues to function effectively for storage and conveyance of floodwater.

8.1.15 The temporary works other than those outlined in Table 6 are considered to be at a low risk of river flooding.

8.2 Surface water/overland flow

8.2.1 The proposed track will result in increased run-off rates due to a reduction in infiltration capacity. Therefore the entire length of the track may be at risk from this source and could increase risk elsewhere.

8.2.2 In addition, the track drainage has the potential to increase flood risk in receiving watercourses if not attenuated. In this study area there are eight proposed balancing ponds, these are located as follows:

- adjacent to the northern end of the Curdworth viaduct (Volume 2: Map CT-06-112b, G7);
- to the east of the Lichfield Road/Faraday Avenue junction (Volume 2: Map CT-06-112b, E6);
- to the west of the route between the Birmingham and Fazeley Canal (CFA20-SW-SW-044) and the Cuttle Mill Fishery (Volume 2: Map CT-06-113, H5);
- at the location of the Cuttle Mill underbridge (Volume 2: Map CT-06-113, F5);
- approximately 450m south of Middleton House Farm (Volume 2: Map CT-06-113, C6);
- adjacent to the southern extent of Middleton House Farm (Volume 2: Map CT-06-114, I7); and
- one to the north and one to the south of the Langley Brook floodplain (Volume 2: Map CT-06-115, F7 and D6).

8.2.3 The outfall from these balancing ponds will be attenuated as described in Volume 1, to ensure that run-off rates are not increased above existing levels to prevent an increase in risk.

8.2.4 The route has the potential to interrupt surface water movement, which could result in an increase in surface water flood risk. The Environment Agency FMfSW indicates that the Proposed Scheme will interrupt one surface water overland flow path in this study area.

8.2.5 To the north of the Birmingham and Fazeley Canal there is an overland flow path not associated with a watercourse. However, surface water at this location flowing away from the Proposed Scheme will discharge in to the tributary of Langley Brook (Volume 5: Map WR-01-034, D5) as it is does currently. Surface water flow paths towards the Proposed Scheme, at this location, will be collected in the proposed drainage and/or a proposed balancing pond prior to being discharged to the Birmingham and Fazeley Canal. Although there will be an interruption to surface water movement at this location, it is considered that there will be no impact on surface water flood risk as a result of the Proposed Scheme at this location.

8.2.6 The potential impact of the Proposed Scheme on surface water movement, not identified as above, will be incorporated within the scheme design. Therefore the works will have no impact on surface water flood risk.

8.2.7 There are other design elements of the Proposed Scheme which will be at risk from surface water flooding. The surface flood risks to the other design elements, as identified from the Environment Agency FMfSW are included in Table 7.

Table 7: Surface water flood risks to other design elements of the Proposed Scheme

Works at risk	Location description	Description of possible influence to the Proposed Scheme	Risk
Highways	Access road from Lichfield Road, north of the River Tame Volume 5: Map WR-01-033, G6	The proposed access road will be located in an area at a low, medium and high risk of surface water flooding. Areas of landscaping will also be in this area at risk.	High
Highways Landscaping	Lichfield Road/Faraday Avenue junction Volume 5: Map WR-01-033, F6	The proposed balancing pond to the north of Faraday Avenue, the associated access road, landscaping and small section of track embankment will be in an area at a low, medium and high risk of surface water flooding.	High
Highways	South west of Marston Volume 5: Map WR-01-033, E6	A proposed footpath will partly cross an area susceptible to surface water flooding. This area is at a low and medium risk of surface water flooding.	Medium
Highways Landscaping	South of Cuttle Mill Fishery Volume 5: Map WR-01-033, D6	The proposed balancing pond to the south of Cuttle Mill Fishery, the associated access road, a small area of the track embankment and landscaping will be in an area at a low and medium risk of surface water flooding.	Medium
Highways Landscaping	Bodymoor Heath Lane Volume 5: Map WR-01-034, E6	The realignment of Bodymoor Heath Lane, the associated embankment and landscaping will be located in areas at a low and medium risk of surface water flooding.	Medium
Highways Landscaping	North of Bodymoor Heath Lane Volume 5: Map WR-01-034, E6	A proposed footpath will partly cross an area susceptible to surface water flooding. Landscaping and earthworks will also be located in this area at low, medium and high risk of surface water flooding.	High
Highways Landscaping	Langley Brook Volume 5: Map WR-01-034, D6	The works to the A4091 Tamworth Road, including the culvert work, earthworks and landscaping will be located in areas at a low, medium and high risk of surface water flooding.	High
Landscaping	Gallows Brook Volume 5: Map WR-01-034, C6	Landscaping and earthworks will be located in areas at a low and medium risk of surface water flooding.	Medium

8.2.8 There are eight locations where other design elements are located in areas susceptible to surface water flooding. In general these areas range from low to high risk and as a conservative approach the highest level of risk has been assigned. Therefore, four of the eight locations are categorised as being at a high risk and four being at a medium risk of surface water flooding.

8.2.9 The other design elements not listed in Table 7 are considered to be at no risk from surface water flooding in line with the flood risk category matrix.

8.2.10 All other design elements, including those additional to Table 7, have the potential to increase surface water run-off rates through reduced infiltration capacity. The design for the Proposed Scheme includes surface water run-off management (such as drainage channels and balancing ponds) to prevent an increased risk of flooding from this source both on site and in neighbouring areas.

8.2.11 Table 8 details the risk to the temporary design elements from surface water flooding.

Table 8: Sources of surface water flooding to temporary works

Description of surface water flooding location	Description of possible influence on temporary design elements	Risk
South of Cuttle Mill Fishery Volume 5: Map WR-01-033, D6	A temporary construction access/haul road and fencing will be located in areas at low and medium risk of surface water flooding.	Medium
Cuttle Mill Fishery Volume 5: Map WR-01-033, D6	A temporary bridge will cross an area susceptible to surface water flooding. The area at risk is at a high risk of flooding. At this location a temporary construction access/haul road and fencing will be located in areas at low risk of surface water flooding.	High
In the vicinity of Bodymoor Heath Lane realignment Volume 5: Map WR-01-034, E6	A temporary bridge, a temporary construction access and Bodymoor Heath Lane overbridge satellite compound will be located in areas at a low and medium risk of surface water flooding.	Medium
Langley Brook Volume 5: Map WR-01-034, D6	A temporary bridge, a temporary construction access/haul road and fencing will cross areas at a low, medium and high risk from surface water flooding.	High
Gallows Brook Volume 5: Map WR-01-034, C6	A temporary construction access/haul road will be located in an area at low and medium risk of surface water flooding.	Medium

8.2.12 There are five locations where temporary design elements in this study area have been identified to be at risk from surface water flooding from the Environment Agency FMfSW. A conservative approach has been taken in categorising risk as outlined earlier in this section. Therefore, in line with the flood risk category matrix (Table 1) a high risk of surface water flooding has been categorised at two locations and a medium risk at three locations.

8.2.13 Construction and satellite compounds have the potential to interrupt surface water flow paths. However, there are no satellite compounds in this study area that will interrupt surface water flow paths which are identified on the Environment Agency FMfSW.

8.2.14 In line with the risk category matrix provided in Table 1, all other locations for temporary works within this study area are classed to be at no risk from surface water flooding.

8.2.15 The works will be completed in line with the CoCP (Section 16 of the draft CoCP) and hence the design of the temporary works will prevent an unacceptable level of surface water flood risk on site.

8.2.16 Temporary works not identified to be at risk on the FMfSW also have the potential to increase flood risk from this source in neighbouring areas as a result of reduced ground permeability. Therefore, in line with the CoCP (Section 16 of the draft CoCP), surface water will be managed at all locations of temporary works, including areas not identified to be at risk from surface water in Table 8. This will ensure that the temporary works are at an acceptable level of risk and will not cause an increased risk elsewhere from surface water flooding.

8.3 Groundwater

8.3.1 The Proposed Scheme within this study area overlies multiple aquifers. However, the works proposed are not expected to increase groundwater flood risk.

8.3.2 The Proposed Scheme will not cut off groundwater flow within shallow aquifers and therefore significant changes to groundwater flood risk are not expected.

8.3.3 It is recognised that groundwater inflow into cuttings and below ground structures may occur; this will be managed by installing drainage to maintain groundwater levels 1m below the top of the rails.

8.3.4 Leeds spur north-east and Leeds spur north-west retaining walls cut across the Glaciofluvial deposits which contain a Secondary A aquifer. These cuttings will be designed as impermeable retained cuttings. The structures have the potential to interrupt groundwater flow which, it is assumed, is towards the east. This interruption has the potential to increase groundwater levels which could lead to groundwater flooding on the western side of the retaining walls.

8.3.5 This risk will be assessed in more detail during the detailed design stage following ground investigation. If necessary, mitigation will be included by proving drainage to ensure that groundwater levels to not rise to a level that creates an increased risk of flooding.

8.3.6 The CoCP will be adhered to and hence the Proposed Scheme will not result in an increased groundwater flood risk to the location of the works or in neighbouring areas.

8.4 Sewer systems

8.4.1 The route crosses the sewer network at one location and will be located within approximately 80m of an inspection cover. However, topography in the area indicates that there are no flow paths for flooding to the Proposed Scheme from this source.

8.4.2 The works will be completed in line with the CoCP (Section 16 of the draft CoCP) and hence will ensure that the Proposed Scheme and neighbouring areas will not be at an increased flood risk from this source. One such measure outlined in the CoCP requires the removal or stopping and sealing of drains and sewers taken out of use. Similarly as outlined in the CoCP, precautions will also be taken to prevent damage to services and to avoid pollution during service diversions, excavations and ground penetration.

8.5 Artificial sources

8.5.1 At locations where the route crosses canals or areas at risk of flooding as a result of reservoir failure, there is potential that the Proposed Scheme may either increase risk from this source, or divert flood water causing new areas to be put at risk.

Reservoirs

8.5.2 The Environment Agency reservoir inundation maps indicate that the area in the vicinity of the River Tame viaducts (Volume 5: Map WR-01-033, G6) would be at risk of flooding following reservoir breaching, as outlined in Section 6.6. The other design elements in this area at risk are landscaping and a proposed access road. The

temporary works at risk are the River Tame viaducts satellite compound (south) and temporary fencing. The reservoir inundation extent in this area is narrower than the areas at risk of river flooding. Therefore it is considered that the vertical clearance required for river flooding would be sufficient to prevent a significant alteration of flood water flow paths and inundation during reservoir flooding.

8.5.3 As outlined in Section 6.6 the area to the north of Middleton House Farm is also located in an area at risk of reservoir flooding (Volume 5: Map WR-01-034, F6). The other design elements at risk in this location are the Bodymoor Heath Lane realignment and associated embankment and landscaping works. The temporary work elements at risk are the Bodymoor Heath Lane overbridge compound and a temporary bridge. At the location where the route will cross the watercourse, the inundation extent is of a similar width as areas at risk from river flooding. However, to the north of Bodymoor Heath Lane the reservoir inundation mapping covers a greater extent than the river Flood Zone mapping and therefore there is potential that the Proposed Scheme may slightly alter flow paths at this location.

8.5.4 The area at the northern boundary of the study area is at risk of flooding should Canwell Reservoir fail (Volume 5: Map WR-01-034, B6). The other design elements in this area at risk are landscaping and earth works, and a temporary bridge is also within this area at risk. As shown on the reservoir inundation mapping, the inundation extent is similar to the areas at risk from river flooding; therefore it is considered that the vertical clearance required for river flooding would be sufficient to prevent a significant alteration of flood water flow paths and inundation during reservoir flooding.

8.5.5 In line with the risk category matrix (Table 1) the flood risk to all elements of the Proposed Scheme from reservoir failure is considered low.

8.5.6 The CoCP (Section 16 of the draft CoCP) outlines that areas at risk of flooding should be considered when planning sites and storing materials. Although the flood risk areas are likely to be taken from the river flood risk maps, at the location at risk from reservoir inundation in this study area, the reservoir inundation maps are smaller than the areas at risk from river flooding. Therefore it is considered that the temporary works will not significantly alter flood flow paths and hence alter flood risk from this source to other receptors. The one exception to this is the Bodymoor Heath Lane overbridge compound which is located in an area not identified to be at risk from river flooding. The management at this site should consider the impact of risk of flooding as a result of reservoir failure, although it is not anticipated that these proposed works would have a significant impact on flood flow routes and hence flood risk to other receptors.

8.5.7 There are no other locations within this study area that are at risk of flooding from reservoir failure as shown on the Environment Agency reservoir inundation maps. It is therefore concluded that the Proposed Scheme, including the route, other design elements and temporary works, will be at a low risk of flooding from this source (Table 1) and will not result in an increased risk elsewhere.

Canals

8.5.8 The proposed route involves development that crosses the Birmingham and Fazeley Canal (Volume 5: Map WR-01-034, H6) in this study area.

8.5.9 The other design elements to the north of this canal, specifically the balancing pond, a mid-point autotransformer substation, track embankments and landscaping are at risk should overtopping occur.

8.5.10 The temporary works at risk are those at the Birmingham and Fazeley Canal viaduct (central) compound which is located between the canal and the M42. This satellite compound would be at a higher elevation than the canal, and hence is not considered to be at risk. The Birmingham and Fazeley Canal viaduct (north) compound is located at a lower elevation than the minor embankment to the north of the canal and hence will be at risk following overtopping from the canal. There are no other temporary works at risk from this source of flooding.

8.5.11 The canal crossing requires a minimum soffit height for navigational purposes and this soffit would be sufficiently high to prevent any impact on flow. Similarly the works will be undertaken in line with the CoCP (Section 16 of the draft CoCP) and hence will ensure the works are at an acceptable level of risk and that the Proposed Scheme will not cause an increased risk elsewhere.

8.5.12 In line with the risk category matrix in Table 1, the risk to the other design elements and the temporary works is low. These works will be completed in line with the CoCP and hence will not impact on flood risk from this source.

8.6 Summary

8.6.1 The Proposed Scheme will be located in areas at risk from river flooding, including at nine watercourse crossings where a very high risk has been assigned. However, the hydraulic modelling completed at these nine locations identifies that at six of the crossings the impact of the Proposed Scheme is negligible. At two crossings, North Wood north culvert and Langley Brook viaduct, the Proposed Scheme would have a minor impact on river flood risk. At Hunts Green underbridge, the hydraulic modelling has indicated a moderate impact on river flood risk. However, at this crossing the modelling has shown that mitigation can be provided upstream of this crossing to reduce change to a negligible impact.

8.6.2 The Proposed Scheme will cross areas susceptible to surface water flooding in eight locations. In general, at each of the areas the risk ranges from low to high, although as a conservative approach the highest level of risk has been assigned resulting in many of the areas being categorised as being at a high risk from surface water flooding. However, the Proposed Scheme will mitigate surface water run-off to ensure that the works are at an acceptable level of flood risk and do not result in an increased risk elsewhere.

8.6.3 The Proposed Scheme involves development within an area at a low risk from groundwater flooding. However, the design involves measures to ensure that the development is an acceptable level of risk and that the Proposed Scheme does not increase flood risk from this source.

8.6.4 The Proposed Scheme including the route, other design elements and the temporary works will be at a low risk of flooding from the sewer network. However, the works will be completed in line with the CoCP (Section 16 of the draft CoCP) and hence will ensure that the Proposed Scheme and neighbouring areas will not be at an increased flood risk from this source.

8.6.5 Water levels within canals are continually maintained and hence the chance of overtopping and thus flood risk from this source is considered low. Similarly, due to the strict monitoring and maintenance requirements, the risk of reservoir flooding to the development is considered low. The design ensures that the Proposed Scheme will not result in an increased risk from this source both to the development and elsewhere.

9 Conclusions

9.1.1 The Proposed Scheme, including the route, other design elements and the temporary works, are to be located within areas potentially at risk from flooding from a range of sources. However, the temporary works will be designed to and will follow the CoCP such that development will be at an acceptable level of risk and will not cause an increased risk elsewhere. The proposed mitigation as part of the permanent works will also ensure that the Proposed Scheme will be at an acceptable level of flood risk and will not result in an increased risk elsewhere.

9.1.2 The magnitude of impact and significance of effects have been based on the Environmental Impact Assessment (EIA) Scope and Methodology Report (SMR, see Volume 5: Appendix CT-001-000/1). Table 9 shows a summary of the sources of flood risk within this study area and the associated magnitude of impact and significance of effects.

9.1.3 In terms of river flooding, the magnitude of impact in this study area of the Proposed Scheme with the floodplain replacement storage is negligible and significance of effects neutral.

9.1.4 Although there are areas of the Proposed Scheme at no, low, medium and high risk from surface water flooding, overall the risk from this source is categorised as high, as a conservative approach. However, the overall magnitude of impact is negligible and the significance is neutral. This has been determined because the design of the permanent works will be in line with the design criteria outlined in Section 3 of this report and that the temporary and construction works assessed as part of this FRA are in line with the draft CoCP.

9.1.5 Although there is one area where the Proposed Scheme could increase groundwater flooding, mitigation will be included to prevent any significant increase in risk.

9.1.6 The risk from sewer flooding is low within this study area, and the overall magnitude is negligible with a neutral significance. This has been determined because the design of the permanent works will be in line with the design criteria outlined in Section 3 of this report and that temporary and construction works assessed as part of this FRA are in line with the draft CoCP.

9.1.7 In this study area artificial sources of flooding (both from reservoir failure and canals) have also been categorised as low, resulting in a low significance of effect.

Table 9: Summary of Flood Risk Receptors showing the overall magnitude of impact and significance of effects

Flood risk receptor	Risk category	Magnitude of impact	Significance of effects
Areas at risk from river flooding	Very High	Negligible	Neutral
Areas at risk from surface water flooding	High	Negligible	Neutral
Areas at risk from groundwater flooding	Low	Negligible	Neutral
Areas at risk from drainage and sewer flooding	Low	Negligible	Neutral
Areas at risk of flooding from artificial sources	Low	Negligible	Neutral

9.2 Residual flood risk to the Proposed Scheme

9.2.1 Residual flood risks arise in situations that are not included in standard design scenarios, for example when a culvert becomes blocked causing flooding upstream. All design is generally undertaken assuming that existing infrastructure is functioning under normal conditions. Consequently, there may be areas where the potential severity of flooding may exceed the design standard under certain circumstances.

Residual flood risks from river sources

River Tame viaduct and Curdworth viaduct

9.2.2 There are existing hydraulic structures both upstream and downstream of the River Tame viaduct and Curdworth viaduct. However, the viaduct would be at a significant height above the floodplain, and hence the residual risks of flooding over and above the design event, and the risk of blockage, would not be significant.

Cuttle Mill underbridge

9.2.3 There is one hydraulic structure in the vicinity of the Cuttle Mill underbridge. This is located upstream of the Proposed Scheme and is the outfall from the water body at Cuttle Mill Fishery. Even though the area at risk of flooding should this water body fail is unknown, the track would be at a significant height above the floodplain and hence the risk to the track is considered low.

North Wood north culvert

9.2.4 There is one existing hydraulic structure in the vicinity of the North Wood north culvert. This structure is an existing access track crossing, located downstream of the proposed culvert. There is potential that blockage at this existing road bridge will impact on flood levels at the location of the Proposed Scheme. However, the downstream constriction is at the same elevation as surrounding ground level and therefore if blockage does occur, causing out of bank flooding, it is anticipated that flood water would bypass the existing crossing and hence not impact on the Proposed Scheme.

Hunts Green underbridge

9.2.5 There is one existing hydraulic structure in the vicinity of Hunts Green underbridge and this is located upstream of the proposed crossing. This existing structure (an A4091 Tamworth Road bridge) is located upstream of the Proposed Scheme and therefore blockage at this structure will not lead to any significant increase in the risk of flooding to the Proposed Scheme. Depending on the constriction on flow caused by the A4091 Tamworth Road bridge, any failure of the structure could potentially cause a minor increase in flood levels at the location of the Proposed Scheme.

Langley Brook viaduct

9.2.6 There are two existing hydraulic structures located in the vicinity of Langley Brook viaduct, these are situated both upstream and downstream of the proposed crossing. However, the viaduct would be at a significant height above the floodplain, and hence the residual risks of flooding over and above the design event, and the risk of blockage, would not be significant.

Gallows Brook culvert

9.2.7 At the location of the proposed Gallows Brook culvert, there are no significant hydraulic structures within the vicinity of the Proposed Scheme that would create additional residual risks to the Proposed Scheme.

Drayton Bassett viaduct

9.2.8 There is one existing hydraulic structure in the vicinity of the Drayton Bassett Viaduct. This structure is the existing Shirrell Drive culvert, located upstream of the Drayton Bassett viaduct, which will be replaced with a new structure following the realignment of this road. Depending on the constriction on flow caused by the new Shirrell Driver culvert, any failure of the structure could potentially cause a minor increase in flood levels at the location of the Proposed Scheme.

Residual flood risks from surface water sources and minor watercourses

9.2.9 All culverts within the Proposed Scheme are designed with a minimum internal headroom of 300mm above the design flood water level to minimise the risk of blockage. Therefore, there are not expected to be any significant increases in risk of flooding at dry valley crossings arising from potential blockage of culverts.

Residual flood risks from groundwater

9.2.10 Groundwater levels rise and fall relatively slowly, and therefore any change in the risk of flooding from this source would be the result of below ground intervention. The risk of groundwater flooding already considered in this FRA presents an absolute risk, and there are no significant residual risks arising from this source.

Residual flood risks from the sewer network

9.2.11 Blockage of underground sewer networks can cause surcharge and associated flooding. At locations where the existing sewer infrastructure will need diverting, any replacement infrastructure would be to at least the same standard as existing. Consequently, no additional residual risk to the Proposed Scheme would be expected as a result of drainage system failure.

Residual flood risks from artificial and surface sources

9.2.12 This assessment considers the potential for total failure of reservoirs and canals, which is deemed to be the most extreme case of flooding from these sources. Therefore it is considered that there are no further residual risks from artificial sources of flood risk.

9.3 Residual effects of the Proposed Scheme on flood risk

9.3.1 All culverts within the Proposed Scheme will be designed to convey the 1 in 100 year (1% annual probability) flow including an allowance for climate change with a minimum internal headroom of 300mm above the design flood water level (to minimise the risk of blockage). Consequently, there would be negligible increase in upstream residual flood risks arising from the introduction of culverts within the Proposed Scheme.

9.3.2 All viaducts within the Proposed Scheme will also be designed to convey the 1 in 100 (1%) annual probability flow with an allowance for climate change. As a minimum the design will ensure a 600mm freeboard will be provided to the bridge soffits above this level, and on main rivers where possible, a freeboard of 1m will be allowed. These freeboards will allow for debris and hence prevent a significant increase in residual risk in upstream areas as a result of the Proposed Scheme.

10 References

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